

*Mayer (A. M.)*

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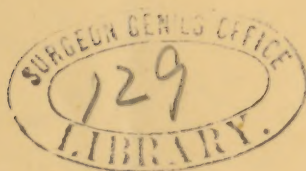
ON A  
PRECISE METHOD OF TRACING THE PROGRESS  
AND OF DETERMINING THE  
BOUNDARY OF A WAVE OF CONDUCTED HEAT.

BY ALFRED M. MAYER, PH. D.,  
Professor of Physics in the Stevens Institute of Technology, Hoboken, N. J.

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IN 1870 Meusel experimented on the formation of double iodides, and on the remarkable changes of color produced in these bodies by heat.\* He prepared a double iodide of copper and mercury, by adding to a warm solution of mercuric iodide in potassium iodide, copper sulphate and then sulphurous acid; the resulting precipitate is of a brilliant carmine red and (in that experimented on by me) turns to a deep chocolate brown on heating to about  $70^{\circ}$  C. In order forcibly to exhibit this change of color, Boettger moistened the iodide with weak gum water, and painted it on paper; on heating the latter, the change of color is produced, and on cooling, the iodide regains its former brilliancy.

Dr. G. F. Barker had the kindness to present me with a card so prepared, and on experimenting with it I soon perceived the valuable means it afforded of tracing the progress and of determining the boundary of a wave of conducted heat. To Dr. Barker I am also indebted for the iodide used in the experiments I here present.

The first use I made of this substance was to track the heat conducted by bars and plates of metal,† and the sharpness of the boundary of the colors instigated me to test the value of this mode of experiment, by applying it to a determination of the elliptical contour of the isothermal of conduction, in the principal section of a quartz crystal.

Sénarmont, in his beautiful researches on this subject (*Ann. de Ch. et de Ph.*, 3<sup>e</sup> S., t. xxi, xxii), has carefully determined

\* *Ber. Berl. Chem. Ges.*, iii, 123, 1870. *Bul. Soc. Ch.*, II, xiii, 220, 1870. *J. Pr. Ch.*, II, ii, 136, Aug., 1870

† The iodide is decomposed by contact with certain metals; these should be coated with a film of collodion, or electrotyped with copper before applying the iodide.

the ratio of the axes of this elliptical figure, by coating a thin longitudinal section of the crystal with wax, and leading through it a silver wire, by means of which heat was brought to the center of the plate, whence it was conducted outward, and its progress and isothermal contour determined by the melting of the wax. The following are Sénarmont's experiments on a plate 27<sup>mm</sup> square, whose sides were parallel and perpendicular to the principal axis of the crystal:

Exp.	Major Axis.	Minor Axis.	Ratios.
1	12.50	9.75	1.28
2	11.60	8.50	1.35
3	10.00	7.50	1.33
4	12.00	9.00	1.33
5	13.75	10.00	1.37
6	18.00	14.00	1.29
7	15.00	12.00	1.25
8	9.75	7.50	1.30

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1.31 Mean Ratio.

Sénarmont, in the above experiments, used every precaution to attain accurate results. He screened the plate from draughts of air and from radiations; kept the plate horizontal and frequently rotated it around its heated wire. After the ellipse had become constant in its form, he allowed the plate to cool, and then measured the axes of the ellipse by means of a micrometer.

In the experiments which follow, I used a quartz plate 27<sup>mm</sup> long, 22<sup>mm</sup> wide, and whose thickness was 1.2<sup>mm</sup>. Its center of figure was pierced by a hole 1.25<sup>mm</sup> in diameter, through which passed the vertical conical end of a silver wire. The iodide was made into a paint with weak gum water, and in experiments 1, 2, 3 and 4 was applied to the surface of the plate by a camel's hair pencil. In experiments 5, 6, 7 and 8, the better plan was adopted of flowing the iodide over the plate, and allowing the water spontaneously to evaporate. Thus we obtain a smooth, evenly distributed coating, giving a sharp outline to the elliptical figure of the conducted heat. The plate was screened from radiations of the flame which heated the wire, but was not shielded from currents of air, nor was unequal radiation of the iodide specially prevented. The method of measurement was as follows: after the ellipse was well formed, and of permanent dimension, the extremities of its longer and of its shorter axes were marked by scratching through the iodide with a very slender steel point; the plate was then removed, and the lengths of the axes determined by means of dividers and a scale divided into half millimeters.

Exp.	Major Axis.	Minor Axis.	Ratios.
1	12·5	9·25	1·35
2	14·0	10·5	1·33
3	17·75	13·5	1·31
4	18·25	14·0	1·30
5	12·75	9·5	1·34
6	12·8	9·5	1·34
7	12·8	9·5	1·34
8	16·4	11·8	1·38

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1·33 Mean Ratio.

An opinion on the relative values of the two modes of experimenting can only be formed from a discussion of the two series of observations by the method of least squares. It is true that the series are not as extended as one would wish for the application of this process, yet its results are equally fair for both. We thus have found that the—

Probable error of a single determination of ratios in S.'s series is	·0267
“ “ “ “ M.'s “	·0170
“ in the mean ratio “ S.'s “	·0094
“ “ “ “ M.'s “	·0060

From these figures we infer that Sénarmont's ratio is barely true to a hundredth, while my result can be relied on to that figure, and if my measures had been made with a micrometer microscope, on a plate protected from unequal radiation, and shielded from currents of air, I would have obtained a ratio reliable to the third decimal place.

To the higher ratio of my determination I attach no importance; I attribute it to the peculiarity of this particular crystal, for several measures on this plate, with a waxed surface, gave even a higher ratio than when the iodide was used. It hence appears that to obtain the correct ratio for a given crystal, the mean ratio derived from several plates should be adopted.

The remarkable change of color which heat produces in this iodide led me to hope that this molecular change would be accompanied by a simultaneous variation in its radiating power. To solve this problem, I made the following experiments, at different temperatures, below and above the degree at which its color changes. One side of a hot-water cube was coated with lamp-black, and another side with a thick paste of iodide and gum-water; after the latter had nearly dried, I sifted iodide over it, and caused this to adhere by rubbing it gently with my finger. The cube was now filled with water, in which was supported a thermometer. The water was raised to the following temperatures, and frequently agitated, so as to ensure a uniform heating of the cube. The deflections produced in the galvanometer needles by the lamp-black, and by the iodide,

were then obtained for each fixed temperature. Each deflection given below is the mean of three experiments.

Temp.	Lamp-black.	Iodide.	Ratio of Deflections.	Changes in Color.
60°	18·75	13·75	1 : ·70	
65°	22·25	17·	1 : ·71	{ Cherry red, and turning in spots to chocolate color.
68°	22·75	16·25	1 : ·71	
70°	24·0	16·87	1 : ·70	{ Dark red, with spots of chocolate color.
72°	25·0	17·62	1 : ·70	
75°	26·25	18·62	1 : ·70	{ Whole surface of a deep brown.
100°	45·0	30·5	1 : ·67	
				{ Deep purplish brown.
				{ “ “
				{ “ “

The last experiment, in which the temperature of the surface was 100°, gave deflections so far exceeding those produced before that I sought to render them comparable by removing the hot water cube to a greater distance from the thermo-battery, when I obtained the following ratio :

Temp.	Lamp-black.	Iodide.	Ratio.
100°	20°	13·41°	1 : ·67

The result was the same ratio as formerly obtained.

These experiments seem to show that the molecular change in the iodide, which causes it to act so differently in reflecting light, does not appear to have any action on its power of radiating the rays of heat of low intensity. I intend, however, to return to this investigation, provided with an apparatus giving the differential actions of two cubes, and having a carefully calibrated galvanometer, and with this arrangement to test the reflecting as well as the radiating power of this and other iodides.

Several applications of this iodide for showing elevations of temperature will naturally present themselves; for example, Foucault's experiment of the heating of a copper disc, when rotating in the magnetic field, can be exhibited to a large audience by painting the disc with this iodide; on the disc attaining 70° C., the brilliant scarlet will change to a deep brown, to regain its former brilliant hue on cooling.

A more useful application may be made of this, or of several other more appropriate metallic compounds, by painting them on the *pillow-blocks*, and other parts of machines which are liable to injurious heating from friction. Thus the machinist can, from the colors of these paints, ascertain the temperature of these sometimes inaccessible parts of moving machines.

May 20, 1872.



